Attachment A.

Responses to Environmental Protection Agency Comments on the Operable Unit 6 Draft Final RFI/RI Report 9/95

General Comments

1 Comment

In discussing the nature and extent of contamination and the potential for migration, the report does not adequately evaluate the role of the groundwater seeps located on the hillsides in several areas CDPHE has raised several serious question about the way in which risk from these areas has been (or not been) calculated EPA believes these seeps play an important role in the movement of contaminants from source areas to the drainages and ponds This migration pathway has for the most part been ignored It will require full evaluation if appropriate management decisions are to be made for remedial responses and protection of surface water

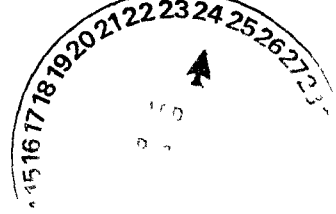
Response

Seeps exist along the south flank of South Walnut Creek in the area east of the surface drainage gully Although the OU 6 work plan and subsequent addenda never directed OU6 to characterize these, some seep investigation was undertaken during the OU 2 RFI/RI OU 6 surface water data and OU 2 groundwater data collected during the RFI/RI (1992) indicated that groundwater contaminant plumes had not yet migrated to the B-series ponds Occasional, sporadic detections of VOCs at low concentrations (less than 10 ppb) had been noted in the area, but nothing that would denote the leading edge of a contaminant plume In addition, groundwater solute transport modeling results reported by OU 2 indicated that the existing groundwater contaminant plumes had already approximately reached steady state conditions, and minimal further migration would be expected

During the time that the OU 2 and OU 6 draft RFI/RI reports were being prepared, further characterization of the seeps and alluvial groundwater upgradient of South Walnut Creek drainage (between the B-series ponds and the OU 2 East Trenches) was initiated by the DOE As reported in the draft *Strategic Plan for the Management and Remediation of Groundwater at the Rocky Flats Environmental Technology Site* (RMRS, 1995), recent data indicate that the leading edge of a VOC groundwater plume from the OU 2 East Trenches area appears to have reached Ponds B-1 and B-2 There is no evidence that any of the other B-series ponds are being, or will be, impacted by the VOC plume originating from the OU 2 East Trenches The draft groundwater strategy plan, which is being developed jointly among DOE, EPA, CDPHE, Kaiser-Hill, and RMRS, further discusses potential source removal from the OU 2 East Trenches and groundwater remediation (e g , plume capture and passive treatment at plume front) to minimize the risk from contaminant migration to the surface water system at South Walnut Creek Because EPA and CDPHE are involved in the development of this plan, they will have every opportunity to provide input into the strategy for protecting this ecological resource

2 Comment

Section 5 0 of the RI discusses the fate and transport of chemicals of concern (COCs) identified by the baseline risk assessment, but does not evaluate the movement of volatile organic compounds (VOCs) in the vicinity of IHSS 166 1, 166 2, and 166 3 Significant groundwater contamination by VOCs has been discovered in these areas The report states that contamination in the groundwater beneath these trenches will be handled under OU7 This is acceptable **only if** the OU7 remedy includes a full assessment and adequate response to these sources We understand that the current plan for closure of OU7 does not incorporate these sources in the remedy design



1/12

Response
The potential groundwater contamination near the OU6 Trenches, south of the OU7 Landfill will be addressed under the Sitewide Groundwater Strategy The results of the Colorado Department of Public Health and Environment (CDPHE) conservative screen on the soil samples collected from IHSSs 166 1, 166 2, and 166 3, as reported in the final OU6 Letter Report (DOE 1994)

3 Comment
Our contractor reviewed the early submittals of the COC selection process and human health risk assessment (HHRA) The attached letter report presents their comments on these sections In general, the COC selection process and HHRA methodology follow EPA guidance However, some potential exposure pathways were not quantitatively evaluated, and several exposure parameters were inappropriately used to estimate chemical intakes The potential exposure pathways should be quantitatively evaluated unless there is justification for exclusion from the quantitative analysis Additionally, inappropriate exposure parameters should be removed from the intake algorithms due to insufficient information available to support their use and the potential for a significant underestimation of risk

Response
See responses to comments numbered 13 through 16

Specific Comments

1 Comment
Page 2-24, Second Paragraph This paragraph discusses soil boring installation and sampling in the Old Outfall Area The text states that samples were collected from the top of the prefill surface and from 2 to 24 inches below the prefill surface There is no explanation in this section, or in Section 3 9 5 2 (geology), of how the prefill surface was identified Soil borelogs in Appendix C-2 4 also do not clarify this distinction An explanation or description of how this prefill surface was identified should be included here or in Section 3 9 5 2

Response
Section 3 9 5 2 identifies the contact between the artificial fill and the Rocky Flats Alluvium (RFA) as a black, fine to coarse-grained unconsolidated sand observed in borings 60192 and 60292

2 Comment
Page 2-33, Last Paragraph This paragraph presents the locations of soil borings in Trenches A, B, and C The text states that subsequent to drilling the eastern portion of Trench C, the IHSS location was revised and relocated south of the borings The reason for the change in the IHSS location is not stated If the IHSS boundary revision is due to aerial photograph interpretation, the results of the geophysical survey, or visible evidence (or lack thereof) in the soil borings, it should be stated in the text

Response
The text is in error The IHSS boundary was never revised and relocated through the Historical Release Report The reason that the boring locations are outside of the IHSS in Trench C East is that the Trench was located using an aerial photo review and geophysical study The text was revised to be more accurate

3 Comment
Figure 2.2-19 This figure shows soil boring and monitoring well locations for IHSSs 166 1-3 The figure shows that no soil borings were placed in the revised location of the eastern portion of

2

Trench C An explanation for this potential data gap should be provided in the text (Also see specific comment number 2)

Response
See the response to comment number 2

4 Comment
Page 2-34, Third Paragraph, and Figure 2.2-19 The text states only one monitoring well (77392) was installed downgradient of Trench B This well has remained dry and has not been developed or sampled Analytical results of subsurface soil samples from Trench B contained elevated concentrations of VOCs, barium, calcium, americium, and uranium The text states that groundwater flow in this area is to the east and south toward North Walnut Creek Either due to dry conditions in this area or to inadequate well placement, groundwater quality downgradient of Trench B may not have been characterized This data gap should be addressed to determine whether contaminants detected in soil have migrated to groundwater

Response
Groundwater is being assessed and characterized on a sitewide basis If there is a problem in this area, it will be identified However, there is little evidence that these trenches are a source of contamination for groundwater The results of the OU6 Letter Report (DOE 1994) conclude that the subsurface soil in the trenches have a risk ratio below 1 DOE will pursue a No Action closure of these IHSSs

Recent studies of this area, including the Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site (April 1995) have determined that monitoring well 77392 is located in an area that is likely unsaturated

Well placement was reasonable considering the topographic and groundwater conditions known at the time

5 Comment
Page 2-38, First Paragraph, and Figures 2.2-20 and 2.2-21 The text states that monitoring wells 77192 and 76792, located downgradient of the North Spray Field Area and South Spray Field Area, are dry Low concentrations of VOCs, metals, and radionuclides were detected in subsurface soil samples from both areas Since no groundwater samples were obtained, groundwater quality downgradient of these areas may not be adequately characterized In addition, two stream sediment samples and one surface water sample were omitted from the sampling program for the North Spray Field Area Therefore, surface water and groundwater data gaps exists along the north branch of the unnamed tributary that flows east from the North Spray Field These data gaps should be addressed to evaluate the nature and extent of contamination in groundwater

Response
The justification for the omission of the two stream sediment samples and one surface water sample from the sampling program for the North Spray Field Area are found in Appendix H (TM1) of the OU6 Work Plan

There is no clear evidence that these IHSSs are a source of contamination for groundwater The results of the OU6 Letter Report concludes that the soil in the original South Area Spray Field have a risk ratio below 1, therefore DOE will pursue a No Action closure of this IHSSs As for the North Area Spray Field, the Human Health Risk Assessment in Appendix J concludes that this IHSS does not pose a risk above the 10^{-6} point of departure DOE will also pursue a No Action closure for this IHSS

3

Well placement was reasonable considering the topographic and groundwater conditions known at the time

6 Comment

Figure 2.2-14 This figure presents stream sediment, soil boring, and monitoring well locations at IHSS 143, the Old Outfall Area The figure shows the approximate boundary of IHSS 143 as extending north across the protected area (PA) fence All sample locations are located south of the PA fence If the outfall discharged to the north (downhill), the samples obtained from the locations shown may not have completely characterized potential contamination at this site This possible data gap should be explained in the text

Response

Although the historical review and aerial photo review determined that the IHSS extends further than delineated by the HRR, most of the IHSS was inaccessible due to obstructions described in Section 2 2 3 such as above-ground and below-ground utilities, the PA security fence, and paved roads The text in Section 8 was revised to include a brief discussion of this potential data gap Figure 2 2-14 was revised to show the correct IHSS boundary

7 Comment

Figure 3.9-1 and 3 9-2 Figure 3 9-2 presents a cross section of the Sludge Drying Beds and shows the thickness of alluvial material beneath the beds As shown on Figure 3 9-1, this 170-foot cross section is tied to only one soil boring (AB-3) Since the thickness of artificial fill shown on the cross section represents conditions in only one soil boring, it should be stated on Figure 3 9-2 that the thickness is primarily inferred In addition, Figure 3 9-2 shows two unlabeled, angle boreholes along the length of the cross section This does not agree with Figure 3 9-1 These figures should be corrected to more adequately present site conditions

Response

Figure 3 9-2 was modified Although the 170-foot cross section is only tied directly to soil boring AB-3, all four soil borings shown on Figure 3 9-1 were used to develop the thickness of the artificial fill shown on the cross section Therefore, the thickness is not primarily inferred

8 Comment

Page 6-35 The text introduces some confusion by stating that the dose conversion factors provided in Table 6 7-3 are in terms of millirem per picoCurie (mrem/pCi) However, the values provided in this table are in terms of sieverts per becquerel To prevent confusion, the text should be revised to reflect this, or the table should be revised to be consistent with the text

Response

The text was changed to reflect the units on Table 6 7-3

9 Comment

Page 6-36 The text states that the total effective dose equivalent (TEDE) was calculated by summing the effective dose equivalent (EDE) and the committed effective dose equivalent (CEDE) The TEDE is merely the sum of the external exposures (deep dose equivalent) and internal exposures (CEDE) The CEDE is calculated using the EDE and assessing a 50 year exposure Therefore, summing both the EDE and CEDE will result in a redundant dose assessment These two factors should not be summed, and the TEDE should be calculated as described The text and calculations should be modified accordingly

4

Response
The definitions for EDE, CEDE, and TEDE, as used in Section 6 7, are given in Appendix J, Section 9 1 The text on pages 6-36 and J9-6 will be modified to clarify the method used as follows

> Estimating Annual Radiation Dose The annual radiation dose is equal to the sum of the CEDEs from all radionuclides taken into the body and the EDEs for all radionuclides external to the body Total annual radiation dose can be compared to annual radiation protection standards, which also reflect this sum

10 Comment
Page I-3, First Paragraph In Appendix I, air modeling, the application of the Ventilated Valley Dispersion Model (VVDM) is discussed for estimating airborne concentrations of particulate matter The discussion is confusing regarding some of the assumptions made The text states, "For this study, no upwind boxes are assumed, therefore, no dilution of ambient concentrations from fresh air entering the box is assumed This is a highly conservative assumption 'Dilution' occurs only as a result of wind flushing the box " It is unclear from the discussion how it is conservative to assume no upwind boxes Furthermore, it is not clear how no air can enter the box on the upwind side, yet air flushes out the downwind side of the box The discussion should be expanded to address the reasons why the chosen approach is conservative, and how conservation of mass is maintained

Response
The text of the first paragraph on Page I-3 of Appendix I is confusing and has been removed from the document A discussion of conservation of mass with respect to pollutant concentrations is presented on Page 1-2 within Second Paragraph Conservation of mass with respect to airflow is inherent with the assumed constant velocity of air moving through the model box The model is conservative because of the assumption that complete mixing occurs instantaneously within the box Therefore, pollutant concentration exposure would also be instantaneous from the beginning of the time step and be maintained the very end of the time step In reality, a period of time within the time step would be required for pollutant concentrations to mix up to the breathing zone

11 Comment
Page I-3, Second Paragraph Regarding the application of the VVDM for estimating airborne particulate concentrations, the second sentence says, "In this case, sequential time steps of 10 seconds are assumed Concentration estimates are made for as many as 360 model time steps every hour " The paragraph should be modified to explain why 10 second time steps are assumed

Response
The text of the second paragraph on Page 1-3 of Appendix I has been modified to address EPA comments and is presented below

"Picking 360 model time steps allows for adequate mixing and an easy way mathematically to calculate emission rates in one hour increments For example, the 360 sequential time steps are assumed to have a 10 second duration so that an emission rate per hour (i e , 360 steps X 10 seconds = 3600 seconds = 1 hour) is obtained in the appropriate units required for use within the Baseline Risk Assessment "

12 Page I-8, Fourth Paragraph Regarding the application of the VVDM for estimating airborne particulate concentrations, the second sentence states, "Then the model was executed only for the total number of hours that exceeded a threshold wind speed of 18 62 meters per second

(m/s) " It appears that this technique was used for both VVDM modeling scenarios the wind erosion scenario and the construction activity scenario Although a threshold wind speed is appropriate for the wind erosion scenario, it is not appropriate for the construction scenario Particulate emissions from construction occur regardless of whether strong winds are present Wind speed is not a variable in the construction activity emission factor that was used The VVDM modeling should be modified so that the construction activity scenario includes all meteorological time periods

Response

Particulate emissions from construction were considered A discussion of emissions from construction is presented in Section 13 "Model Input Parameters" of Appendix I A heavy construction emission factor of 1 2 tons/acre-month of activity from AP-42, Section 11 2 4 of EPA's publication "Compilation of Air Pollutant Emission Factors" (EPA 1993b) is used for modeling In addition, wind erosion emissions from disturbed construction areas are estimated from the AP-42, Section 8 19 1 emission factor of 1 7 lb/acre-day (EPA 1993b) However, EPA's comment is valid in that only those time periods where the wind velocity exceeded 18 62 m/s were modeled We agree that this may not be appropriate for a construction worker scenario where dust is produced from construction regardless of the wind speed The time and expense of additional modeling was determined to be prohibitive However, instead of re-running the model again for all time periods as EPA suggested, it was decided to conservatively estimate risk without modeling, using the default particulate emission factor (PEF) from EPA In comparing the risks estimated using modeled concentrations with those estimated using the PEF (see tables at the end of Attachment A), it can be seen that the risks are very similar Therefore, DOE has decided not to change the HHRA or re-run the air model

EPA RISK ASSESSMENT COMMENTS ON OU6

PRC Comments and Responses

13 Comment

The COC selection process generally follows the COC selection methodology outlined in the Rocky Flats Plant Final Human health risk assessment template (EPA 1994) They were eliminated based on professional judgment (such as spatial and temporal distributions, geochemical characteristics, and presence of high total suspended or dissolved solids in ground water) Several chemicals were eliminated as COCs even though their concentrations significantly differed from background concentrations However, if it is determined by statistical analyses that site chemical concentrations differ significantly from background concentrations, they should be retained as COCs Professional judgment should only be applied when deciding whether to include, not exclude, chemicals as COCs Chemicals that are significantly different from background should not be eliminated as COCs based on professional judgment

Response

Professional judgment and geochemical analyses is Phase V of the Gilbert Methodology (Gilbert, 1993), which is the method of background comparison agreed upon for use at Rocky Flats by DOE, EPA, and CDPHE In addition, the COCs selected for use in the OU6 HHRA were approved by EPA and CDPHE when Technical Memorandum #4, Chemicals of Concern, was approved (EPA, 1994) The one exception was arsenic in sediments, which EPA did not concur with at the time However, in a subsequent meeting with the agencies on February 16, 1995, it was agreed that the presence of arsenic onsite is likely due to background occurrences Arsenic was retained as a chemical of interest and compared to background in Section J10 0, Uncertainties and Limitations

14 Comment

Additionally, calcium, iron, magnesium, potassium, and sodium were eliminated as COCs because they are considered essential nutrients, occur naturally in the environment, and are toxic only at very high doses Before chemicals are eliminated based on essential nutrient status, chemical concentrations should be compared to recommended daily allowances (RDAs) or safe and adequate daily dietary intakes (SADDIs) (EPA 1994) If comparisons reveal that essential nutrients do not pose a health hazard, they can be safely eliminated from the HHRA It is not likely that any of the essential nutrients will be included as COCs but the comparison is necessary

Response

See response to comment #1

15 Comment

Several potentially complete exposure pathways were not evaluated in the HHRA It is noted that "a potentially complete pathway was not assessed when, based on professional judgment and logic, the contribution of the pathway to overall exposure is likely to be orders of magnitude lower than exposure from other pathways, and the pathway is not expected to contribute significantly to overall risk to the receptor " However, it is premature to determine the relative significance of each exposure pathway before risks are quantified Furthermore, EPA guidance (1989) states that all complete pathways should be evaluated unless there is justification to eliminate a pathway from quantitative analysis The additional exposure pathways that need to be quantitatively evaluated in the HHRA include inhalation of volatiles and internal exposure to radionuclides for all receptors, and exposure to surface soil for construction workers

Response

The exposure pathways presented in the HHRA were previously presented in Technical Memorandum No 2, which was reviewed and commented upon by the agencies Any outstanding sitewide exposure scenario issues were resolved in the February 21, 1995 meeting between EPA, CDPHE, DOE, and EG&G These issues were not among those that required resolution However, the following is presented to reiterate the rationale for excluding these pathways from the HHRA

- Inhalation of VOCs released to outdoor air through volatilization from soil or groundwater is considered a negligible pathway for all receptors Volatile chemicals in surface soils, if once present, will have already volatilized, VOCs released from groundwater will be significantly retarded through the subsurface soil and diluted in the ambient air, and VOCs released from subsurface soil upon excavation will also be diluted to negligible concentrations in the outdoors Inhalation of VOCs migrating from groundwater through building foundations into indoor air was assessed for the future office worker in AOC No 2, the maximum risk is estimated at 3 23E-14 The risk due to outdoor exposures would be even lower due to the factors discussed above The value for indoor exposure is negligible compared to the total estimated risk for this receptor--5 18E-07
- The construction worker scenario characterizes inhalation risks from VOCs in subsurface soils There were no VOCs that were determined to be COCs in subsurface soils in OU6
- Internal exposure to radionuclides for all receptors is addressed through evaluation of the inhalation and ingestion pathways in the HHRA
- The HHRA does evaluate the inhalation pathway for exposure of airborne particulates released from surface soil to construction workers However, the future construction worker exposure scenario was developed for the express purpose of assessing subsurface soils because no other exposure scenarios assess this environmental media, all of the other exposure scenarios directly assess risks from surface soils Due to adequate characterization of risks from surficial soils, it has been previously agreed upon by DOE, EPA, and CDPHE that the construction worker exposure scenarios would only

assess exposures to subsurface soils Based on this agreement, COCs and exposure scenarios were developed and approved for use for surface soils and subsurface soils separately

16 Comment

Several exposure parameters in the intake algorithms should not be used because there is insufficient information to support their use Additionally, they could result in a significant underestimation of the risk Exposure parameters that should not be used include fraction contaminated (FC), matrix effect (ME), and particulate deposition factor in lungs (DF)

a The FC exposure factor represents the contact rate However, adjustments in exposure frequency, duration, and intake rate parameters account for exposures that occur less than 100 percent of the exposure time Use of the FC parameter can greatly underestimate risk Additionally, adjustments should be made based on site-specific information about the receptor and receptor behavioral patterns

Response

EPA guidance on calculation of intakes for incidental ingestion of soil includes the use of the parameter "fraction ingested from contaminated source " In RAGS (EPA, 1989) guidance is given to "consider contaminant location and population activity patterns " In the EPA draft document on CT and RME values (EPA, 1993) it is "advocated that this factor *be given consideration*" (EPA's italics) In Attachment J2, "Exposure Factors Tables," all the FC values for soil ingestion are equal to 1 0 in the reasonable maximum exposure (RME) case for all exposure scenarios EPA directed this approach in a letter dated April 11, 1995 The CT value for FC is 0 9 for all scenarios used in OU6 except for the open space scenario, which does not include a FC parameter It has been agreed in discussions with EPA and CDPHE that this is reasonable for noncontact workers at RFETS due to movement of workers around the plant site

b The ME factor was used to account for decreased dermal absorption and bioavailability of specific chemicals However, prior to using any ME factors, soil type on which the ME is based should be compared to site-specific conditions If soil types are dissimilar, then the ME cannot be used to estimate the various intakes Previously, EPA requested that ME factors be submitted for approval prior to use in the risk assessment Until there is EPA concurrence, the ME factor should not be used in the exposure equation and no adjustments should be made for bioavailability

Response

DOE disagrees that use of a soil matrix effect to estimate absorption of a compound through the gut wall is inappropriate EPA approved toxicity criteria (reference doses and cancer slope factors) are derived from studies in which the compound is administered in a readily absorbed form (e g , food, water, corn oil) For virtually all compounds considered in RFETS risk assessment, absorption of these compounds when ingested in a soil matrix would be expected to be considerably less than that from a diet-based matrix Nevertheless, assumptions concerning soil matrix effects in RFETS risk assessments have generally defaulted to 1 (100% absorption) when the data support the assumption or information is insufficient to support an assumption of lower absorption For compounds where literature-based information indicated decreased absorption, a conservative assumption of 0 5 (50% absorption) was assumed, even when literature-based values supported estimated of much lower absorption For example, in the OU6 HHRA, a matrix effect for metals of 0 5 was conservatively assumed In an EPA publication on metals bioavailability, the matrix effect for metals in the diet was between 0 01 and 0 03 (EPA, 1990) It should also be noted that use of the 0 5 matrix effects was only applied to a single compound (Aroclor 1254) that contributed significantly to overall risk There is acceptable precedence for this assumption because the EPA assumed an 'ingestion absorption fraction" from soil of 0 3 in developing its PCB spill policy (Labieniec et al , 1994)

8

Although geochemical speciation studies would be useful for metals, speciation can generally be inferred with confidence from literature-derived data when applied to RFETS-specific data on soils EPA Region VIII have successfully, over several years, performed bioavailability studies on specific metals (e g , arsenic) However, to undertake such studies on multiple compounds would be an enormous undertaking DOE considers, due to the considerations summarized herein, that use of the matrix effect is both scientifically defensible and conservative Therefore, the matrix effect values stated in the OU6 HHRA will not be changed

c The DF parameter was used to estimate the amount of inhaled particulate that is deposited in the lungs In general, a DF may be used to represent the amount of respirable contaminated particulate matter (PM_{10}) that is present in the air, but should not be used to decrease the exposure concentration if the concentrations in air already represent the PM_{10} fraction Furthermore, if it is assumed that only a percentage of the particulates will deposit in the lungs, the remaining percentage will either be swallowed or expectorated Therefore, the ingestion equation should be revised to account for the portion of inhaled particulates that is swallowed However, it would be more appropriate to eliminate the factor from the reasonable maximum exposure (RME) inhalation equation for all receptors, as was stated by EPA in the April 11, 1995 letter and in previous discussions between EPA and DOE

Response

DOE agrees that the use of the depositional factor is inappropriate if the respirable fraction is used or if suspended particulates are expressed as PM_{10} This parameter was originally added to the sitewide exposure factor tables in response to a request by EPA representatives at the December 12, 1994 meeting The depositional factor will be removed from the exposure factor tables and from the intake equations, the risks will be recalculated for the inhalation pathways

Attachment A

REFERENCES

DOE, 1994 *Letter Report on the Colorado Department of Public Health and Environment Source Area Delineation and Risk-Based Conservative Screen and Environmental Protection Agency Areas of Concern Delineation for the Human Health Risk Assessment, Walnut Creek Priority Drainage, Operable Unit No 6* U S Department of Energy, Rocky Flats Field Office, Rocky Flats Environmental Technology Site, Golden, CO (October)

EPA, 1989 *Risk Assessment Guidance for Superfund, Vol I, Human Health Evaluation Manual (Part A),* EPA/540/1-89/002

EPA, 1990, *Metals Bioavailability and Disposition Kinetics Research Needs Workshop,* Office of Research and Development, Research Triangle Park

EPA, 1993 *Superfund's Standard Default Exposure Factors for the Central Tendency and the Reasonable Maximum Exposure (Draft),* EPA, Washington, D C

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Labieniec, P A , Dzombak, D A , and Siegrist, R L , 1994 *Risk Variablity from Uniform Soil Remediation Goals for PCBs,* Journal of Environmental Engineering, Vol 120, No 3, May/June

RMRS, 1995 *Strategic Plan for the Management and Remediation of Groundwater at the Rocky Flats Environmental Technology Site (Draft)* RFETS, RF/ER-95-0121 UN, Golden, CO (December)

Attachment A:

Estimated Risk to Future Onsite Construction Worker from Particulate Inhalation of Surface and Subsurface Soil in OU6 AOC No 1

Chemical Intake Factor = (IRxRFxETxEFxED)/(BWxAT)
Radionuclide Intake Factor = IRxRFxETxEFxEDxCF

Exposure Factors Description	Chemical Units	Exposure Value	
		Central Tendency	Reasonable Maximum Exposure
Inhalation Rate (IR)	m^3/hr	1 25	1 4
Respirable Fraction (RF)[1]	unitless	1	1
Exposure Time (ET)	hr/day	7 2	8
Exposure Frequency (EF)	days/year	30	30
Exposure Duration (ED)	years	1	1
Conversion Factor (CF)	g/kg	1000	1000
Body Weight (BW)	kg	70	70
Carcinogenic Averaging Time (AT)	days	25550	25550
Noncarcinogenic Averaging Time (AT)	days	365	365

NONCARCINOGENIC EFFECTS (HQ = ACxIF/RfD)

CENTRAL TENDENCY

Chemical	Air Concentration (AC)[1] (mg/m^3)	Intake Factor (IF) (m^3/kg-day)	Intake (mg/kg-day)	Inhalation Reference Dose (RfD) (mg/kg-day)	Hazard Quotient (HQ)
Barium	2 79E-08	1 06E-02	2 95E-10	1 40E-04	2 11E-06
				TOTAL	**2 11E-06**

REASONABLE MAXIMUM EXPOSURE

Chemical	Air Concentration (AC)[1] (mg/m^3)	Intake Factor (IF) (m^3/kg-day)	Intake (mg/kg-day)	Inhalation Reference Dose (RfD) (mg/kg-day)	Hazard Quotient (HQ)
Barium	2 79E-08	1 32E-02	3 67E-10	1 40E-04	2 62E-06
				TOTAL	**2 62E-06**

CARCINOGENIC RISK FOR RADIONUCLIDES (CR = AxIFxSF)

CENTRAL TENDENCY

Radionuclide	Air Activity (A)[1] (pCi/m^3)	Intake Factor (IF) (m^3)	Intake (pCi)	Slope Factor (SF) (Risk/pCi)	Carcinogenic Risk (CR)
Americium-241	3 54E-11	2 70E+05	9 56E-06	3 85E-08	3 68E-13
Plutonium-239/240	6 59E-11	2 70E+05	1 78E-05	2 78E-08	4 94E-13
Uranium-233/234	1 73E-10	2 70E+05	4 67E-05	1 40E-08	6 53E-13
Uranium-238	3 33E-10	2 70E+05	8 98E-05	1 24E-08	1 11E-12
				TOTAL	**2 63E-12**

REASONABLE MAXIMUM EXPOSURE

Radionuclide	Air Activity (A)[1] (pCi/m^3)	Intake Factor (IF) (m^3)	Intake (pCi)	Slope Factor (SF) (Risk/pCi)	Carcinogenic Risk (CR)
Americium-241	3 54E-11	3 36E+05	1 19E-05	3 85E-08	4 58E-13
Plutonium-239/240	6 59E-11	3 36E+05	2 21E-05	2 78E-08	6 15E-13
Uranium-233/234	1 73E-10	3 36E+05	5 81E-05	1 40E-08	8 13E-13
Uranium-238	3 33E-10	3 36E+05	1 12E-04	1 24E-08	1 39E-12
				TOTAL	**3 27E-12**

(1) The Air Concentration is calculated by multiplying the soil concentration by 1/4630000000 4 63E+9 m^3/kg is the particulate emission factor The RF of 1 was chosen because the air concentration is already assumed to represent the PM_{10} fraction the RF was included in the calculations for the PEF (see EPA 1991)

Attachment A

Estimated Risk to Future Onsite Construction Worker from Particulate Inhalation of Surface and Subsurface Soil in OU6 AOC No 2

Chemical Intake Factor = (IRxRFxETxEFxED)/(BWxAT)
Radionuclide Intake Factor = IRxRFxETxEFxEDxCF

Exposure Factors Description	Chemical Units	Exposure Value	
		Central Tendency	Reasonable Maximum Exposure
Inhalation Rate (IR)	m^3/hr	1 25	1 4
Respirable Fraction (RF)[1]	unitless	1	1
Exposure Time (ET)	hr/day	7 2	8
Exposure Frequency (EF)	days/year	30	30
Exposure Duration (ED)	years	1	1
Conversion Factor (CF)	g/kg	1000	1000
Body Weight (BW)	kg	70	70
Carcinogenic Averaging Time (AT)	days	25550	25550
Noncarcinogenic Averaging Time (AT)	days	365	365

NONCARCINOGENIC EFFECTS (HQ = ACxIF/RfD)

CENTRAL TENDENCY

Chemical	Air Concentration (AC)[1] (mg/m^3)	Intake Factor (IF) (m^3/kg-day)	Intake (mg/kg-day)	Inhalation Reference Dose (RfD) (mg/kg-day)	Hazard Quotient (HQ)
Barium	3 45E-08	1 06E-02	3 64E-10	1 40E-04	2 60E-06
				TOTAL	**2 60E-06**

REASONABLE MAXIMUM EXPOSURE

Chemical	Air Concentration (AC)[1] (mg/m^3)	Intake Factor (IF) (m^3/kg-day)	Intake (mg/kg-day)	Inhalation Reference Dose (RfD) (mg/kg-day)	Hazard Quotient (HQ)
Barium	3 45E-08	1 32E-02	4 54E-10	1 40E-04	3 24E-06
				TOTAL	**3 24E-06**

CARCINOGENIC RISK FOR RADIONUCLIDES (CR = AxIFxSF)

CENTRAL TENDENCY

Radionuclide	Air Activity (A)[1] (pCi/m^3)	Intake Factor (IF) (m^3)	Intake (pCi)	Slope Factor (SF) (Risk/pCi)	Carcinogenic Risk (CR)
Americium-241	2 73E-10	2 70E+05	7 38E-05	3 85E-08	2 84E-12
Plutonium-239/240	6 30E-10	2 70E+05	1 70E-04	2 78E-08	4 73E-12
Uranium-233/234	1 70E-10	2 70E+05	4 58E-05	1 40E-08	6 41E-13
Uranium-238	1 71E-10	2 70E+05	4 62E-05	1 24E-08	5 73E-13
				TOTAL	**8 78E-12**

REASONABLE MAXIMUM EXPOSURE

Radionuclide	Air Activity (A)[1] (pCi/m^3)	Intake Factor (IF) (m^3)	Intake (pCi)	Slope Factor (SF) (Risk/pCi)	Carcinogenic Risk (CR)
Americium-241	2 73E-10	3 36E+05	9 18E-05	3 85E-08	3 53E-12
Plutonium-239/240	6 30E-10	3 36E+05	2 12E-04	2 78E-08	5 89E-12
Uranium-233/234	1 70E-10	3 36E+05	5 70E-05	1 40E-08	7 98E-13
Uranium-238	1 71E-10	3 36E+05	5 75E-05	1 24E-08	7 14E-13
				TOTAL	**1 09E-11**

(1) The Air Concentration is calculated by multiplying the soil concentration by 1/4630000000 4 63E+9 m^3/kg is the particulate emission factor The RF of 1 was chosen because the air concentration is already assumed to represent the PM_{10} fraction the RF was included in the calculations for the PEF (see EPA 1991)

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